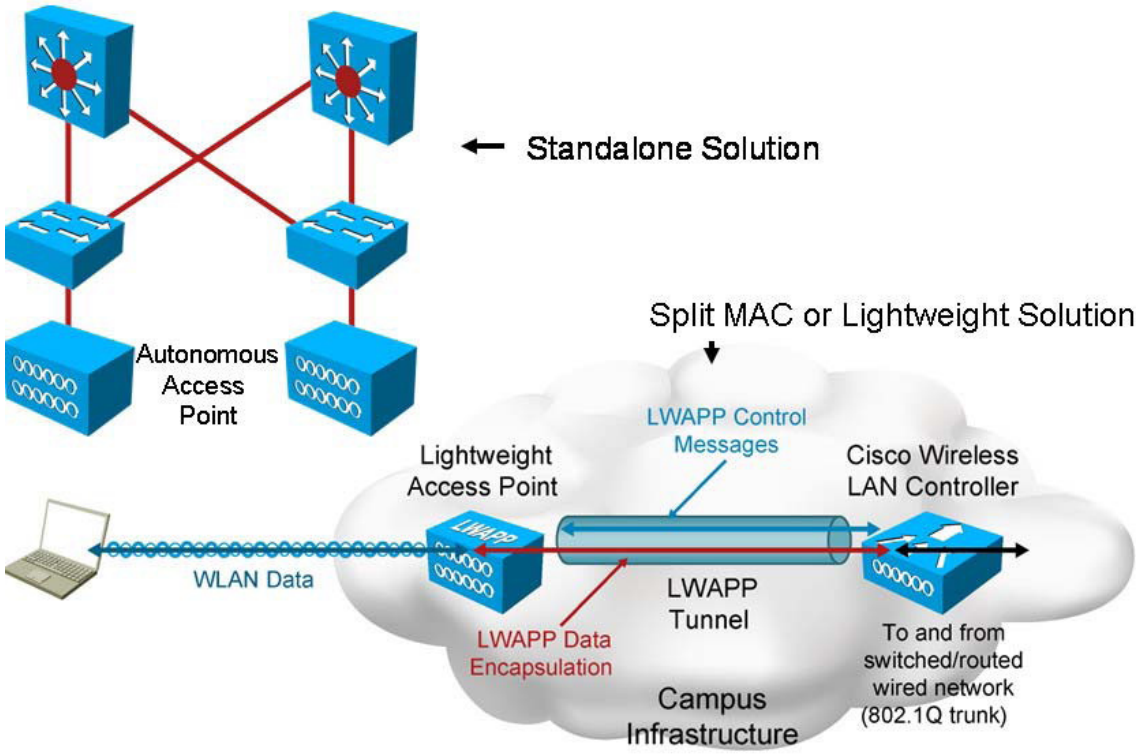
Chapter 8 – Troubleshooting Converged Networks
Objectives

- Explain the operation of the Cisco Centralised Wireless model.
- Describe LWAPP operation & troubleshooting techniques.
- Explain the requirement for QoS converged networks.
- Describe basic QoS operation & troubleshooting techniques.
- Describe basic multicast operation & troubleshooting techniques.

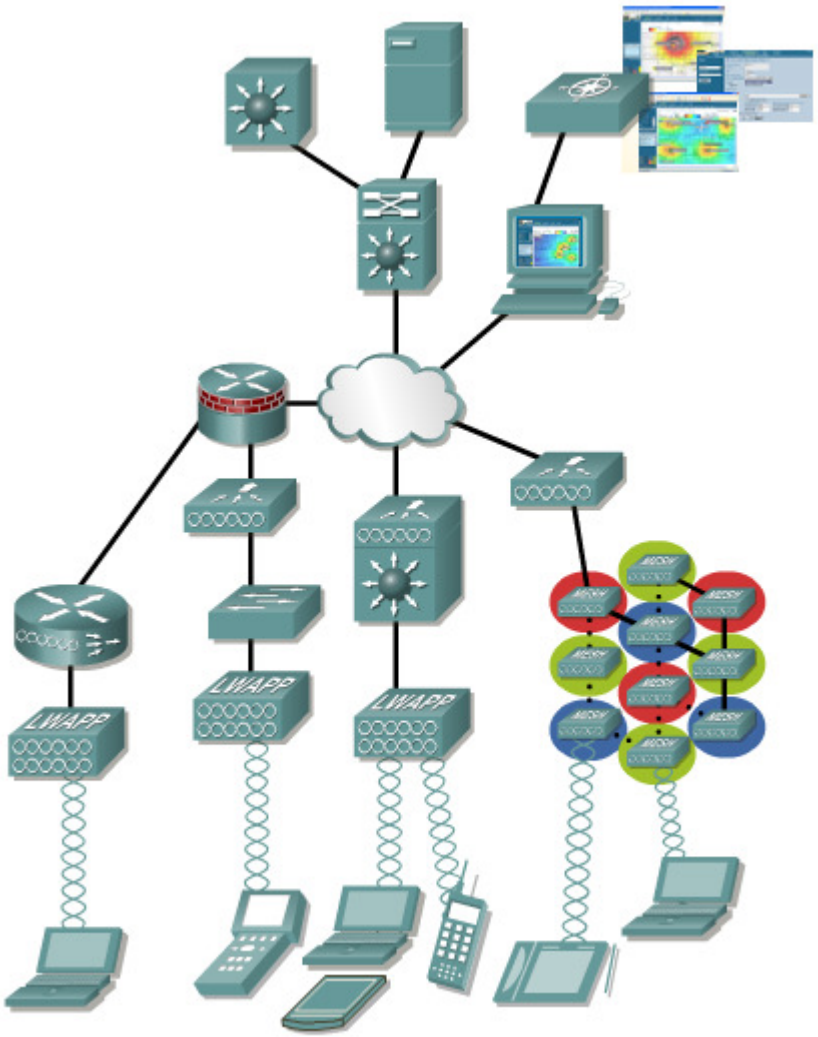
Autonomous or Lightweight?

- Most Cisco wireless access points/bridges are available as **autonomous** or **lightweight** devices.
- Lightweight APs (LWAP) use *Lightweight Access Point Protocol* (LWAPP) and must have a Wireless LAN Controller (WLC) to function within the network.

- Most Cisco autonomous APs can be software upgraded to function as lightweight APs.



Cisco Unified Wireless Network



Unified Advanced Services

•Unified cellular and Wi-Fi VoIP. Advanced threat detection, identity networking, location-based security, asset tracking and guest access.

World-Class Network Management

•Same level of security, scalability, reliability, ease of deployment, and management for wireless LANs as wired LANs.

Network Unification

Integration into all major switching and routing platforms. Secure innovative WLAN controllers.

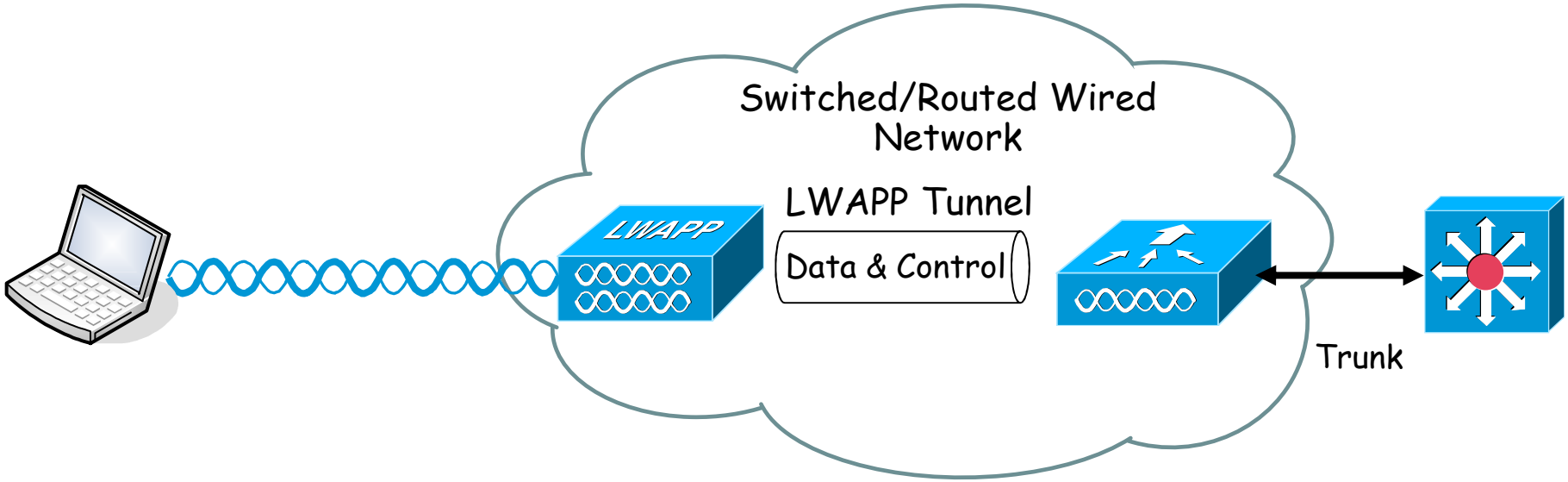
Mobility Platform

Ubiquitous network access in all environments. Enhanced productivity. Proven platform with large install base and 63% market share. Plug and Play.

Client Devices

90% of Wi-Fi silicon is Cisco Compatible Certified. "Out-of-the-Box" wireless security.

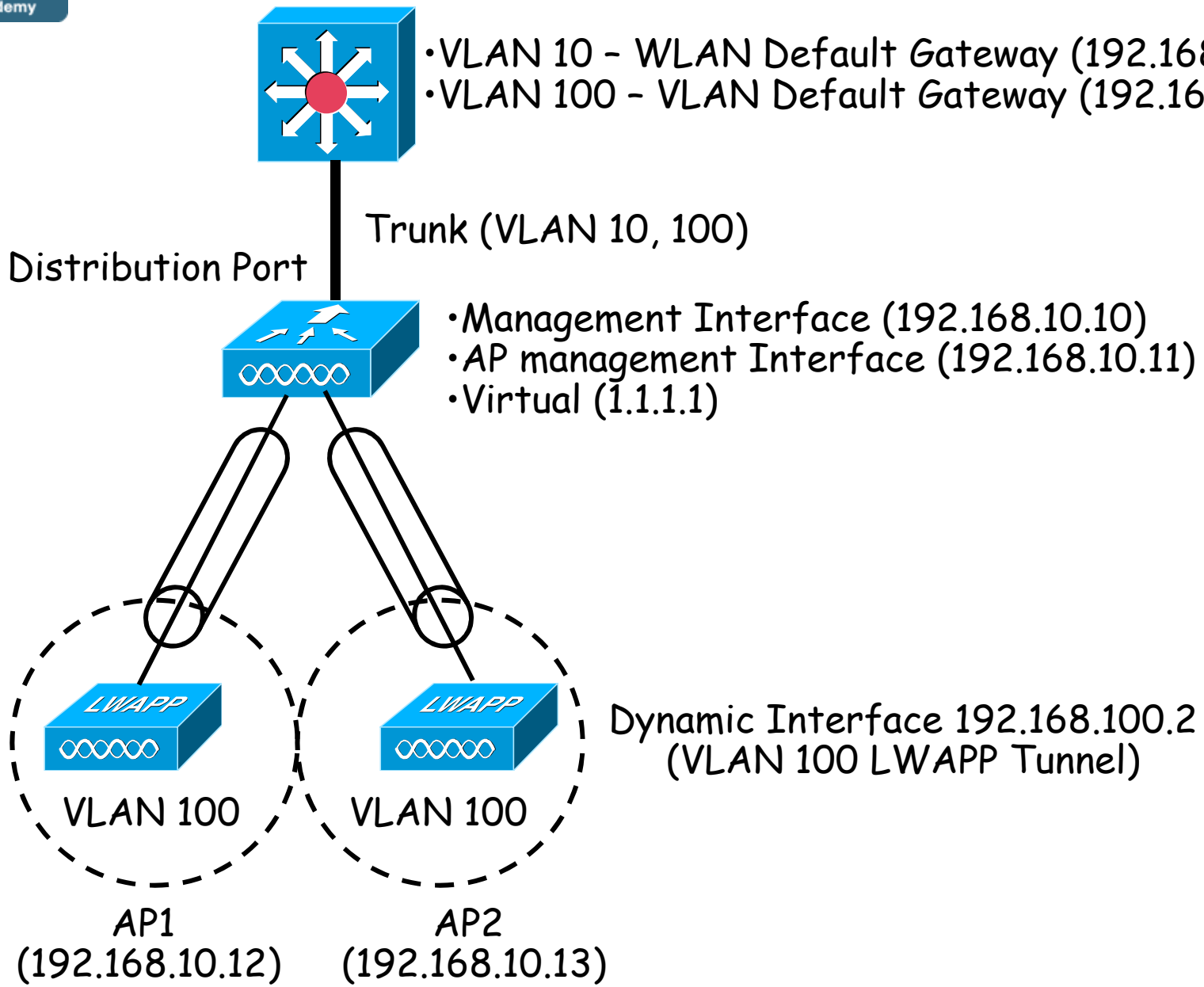
Cisco Centralized WLAN Model



- The *control* traffic between the access point and the controller is encapsulated by Lightweight Access Point Protocol (LWAPP), and encrypted via the Advanced Encryption Standard (AES).

- The *data* traffic between the access point and controller is also encapsulated with LWAPP, but not encrypted.

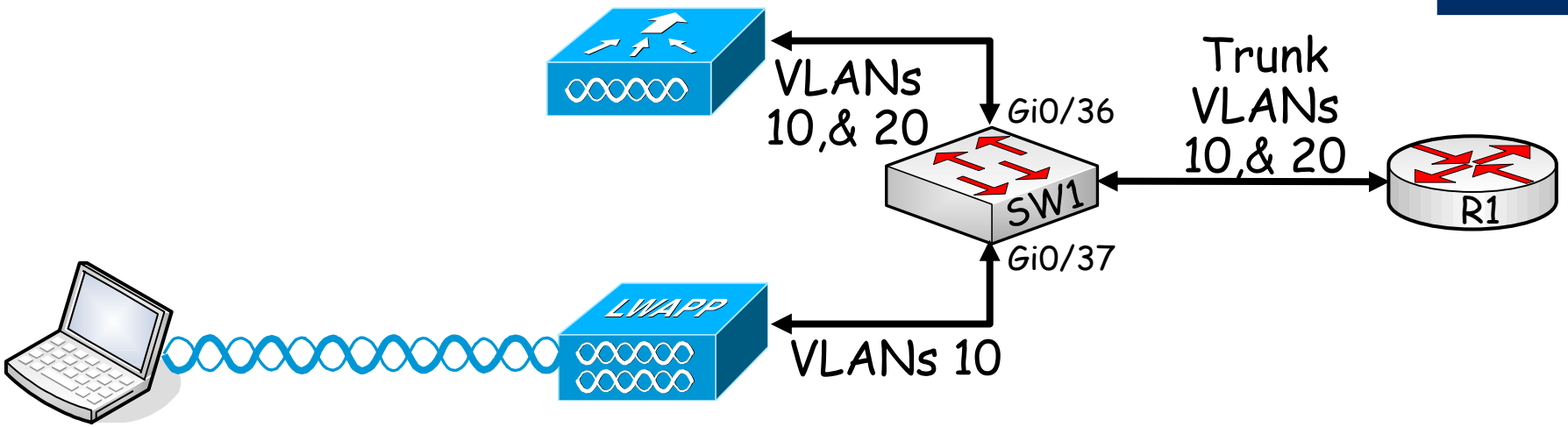
Wireless LAN Controller Interfaces



Wired Network Issues Impacting on WLANs

- Many issues that might be perceived as wireless problems result from underlying issues on the wired network:
- *PoE* - WAPs are often installed away from power outlets, and require Power over Ethernet (PoE) to provide a 48vdc supply over their data connection.
- *VLANs* - wireless users might experience connectivity issues if traffic from their wireless VLAN is not permitted over a trunk in the wired network.
- *Security* - UDP ports 12222 and 12223 are used by LWAPP and should be permitted between a WAP and a WLC.
- *DHCP* – WLANs rely on DHCP to provide roaming clients with IP addresses.
- *QoS* -Latency-sensitive traffic traveling over a wireless network might suffer from poor performance if QoS markings are not preserved as traffic crosses the boundary between the wireless and wired portions of a network.

WLAN Troubleshooting Example 1

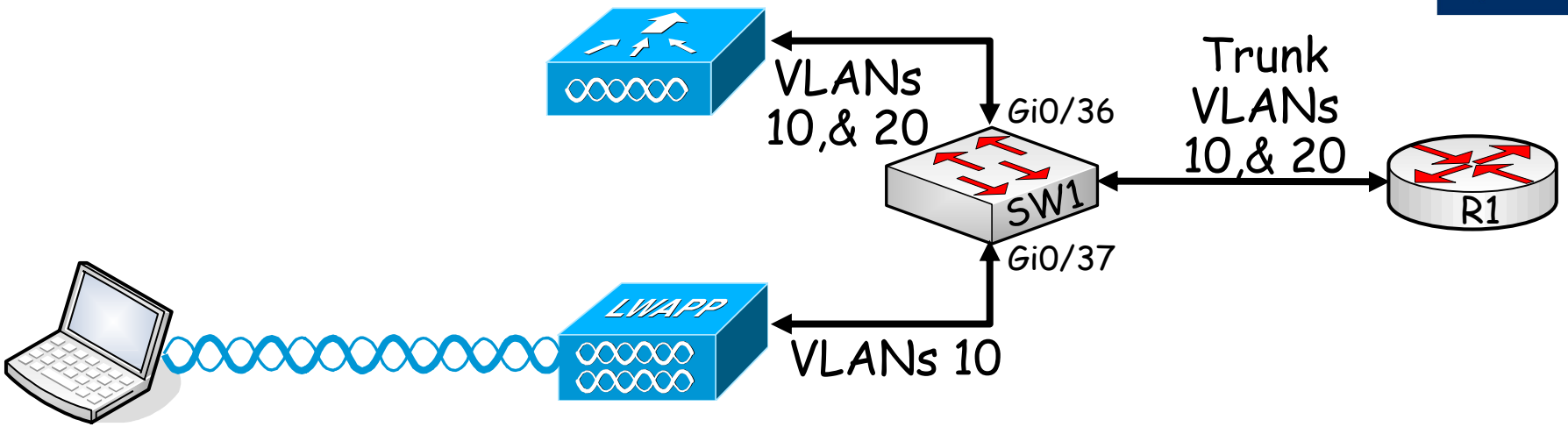


- Wireless services have suddenly stopped; clients are not able to associate to the AP. Even from the wired PCs that are used for troubleshooting, it is not possible to connect to the AP or the WLC, using either SSH or HTTPS

SW1#**show cdp neighbors**
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone

Device ID	Local Intrfce	Holdtme	Capability	Platform	Port ID
ap	Gig 0/37	128	T I	AIR-LAP125	Gig 0
521-8	Gig 0/39	135		AIR-LAP521	Fas 0
521-7	Gig 0/34	122		AIR-LAP521	Fas 0
Cisco_9a:8c:e0	Gig 0/36	175	H	AIR-WLC210	Unit - 0 Slot - 0 Port - 1

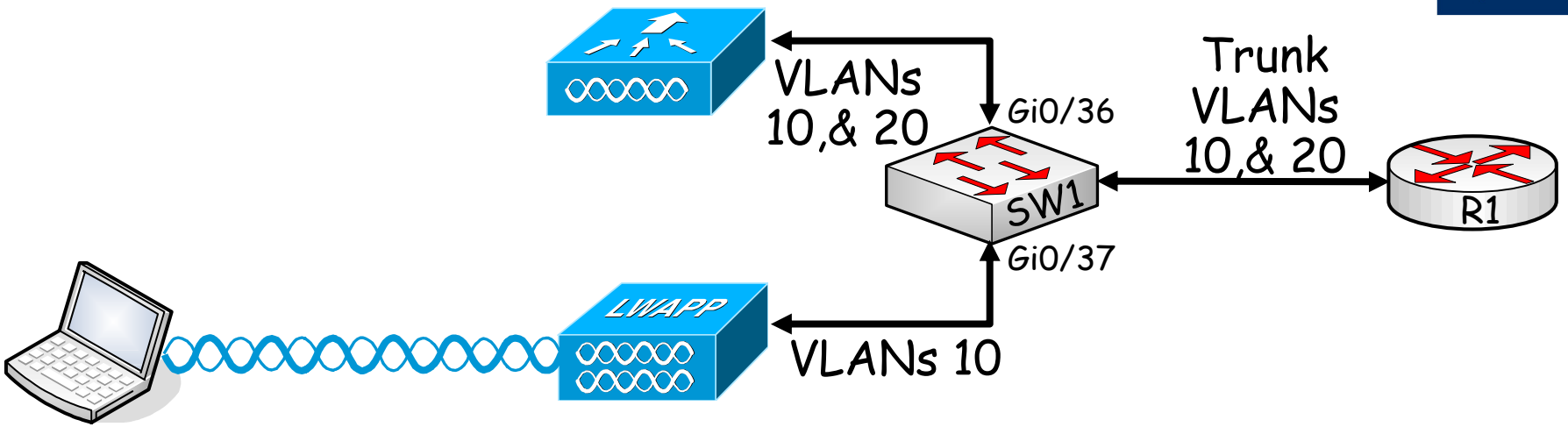
WLAN Troubleshooting Example 1



SW1#show interface status

Port	Name	Status	vlan	Duplex	Speed	Type
Gi0/1		notconnect	1	auto	auto	10/100/1000BaseTX
Gi0/2		notconnect	1	auto	auto	10/100/1000BaseTX
! output omitted for brevity						
Gi0/34		connected	1	a-full	a-100	10/100/1000BaseTX
Gi0/35		notconnect	1	auto	auto	10/100/1000BaseTX
Gi0/36		connected	trunk	a-full	a-100	10/100/1000BaseTX
Gi0/37		connected	10	a-full	a-1000	10/100/1000BaseTX

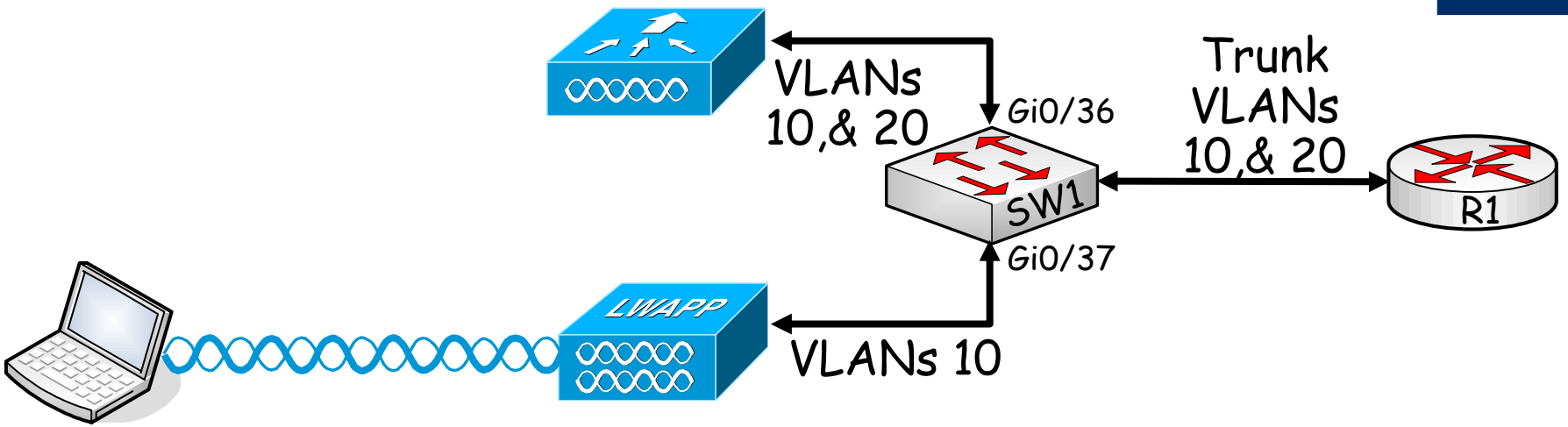
WLAN Troubleshooting Example 1



SW1#show interfaces switchport | begin 0/36
Name: Gi0/36
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
! output omitted for brevity
Trunking VLANs Enabled: 1

SW1(config)#int g0/36
SW1(config-if)#switchport trunk allowed vlan add 10,20
SW1(config-if)#end

WLAN Troubleshooting Example 2



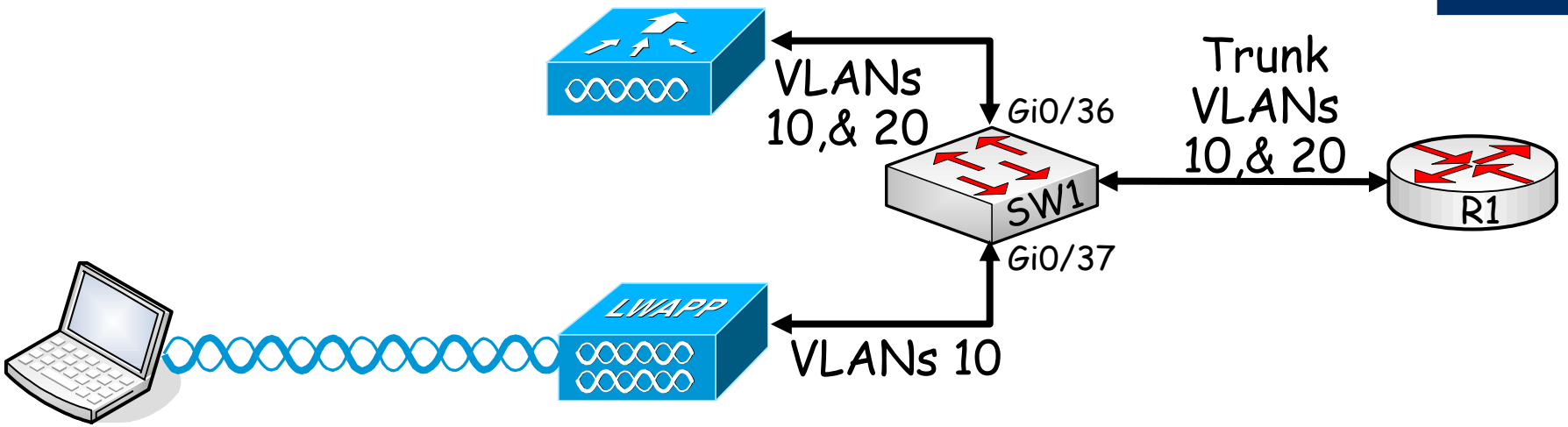
- Wireless services are now available, but wireless users are still experiencing performance issues, especially with VoIP traffic.

```
SW1#show mls qos int g0/37
GigabitEthernet0/34
trust state: not trusted
trust mode: not trusted
trust enabled flag: ena
COS override: dis
default COS: 0
DSCP Mutation Map: Default DSCP
Mutation Map
Trust device: None
qos mode: port-based
```

- A *trust boundary* is the point within the network where QoS markings such as DSCP are first accepted.

- By default, switch ports will *reset* DSCP values unless you *explicitly* tell the port to trust those values.

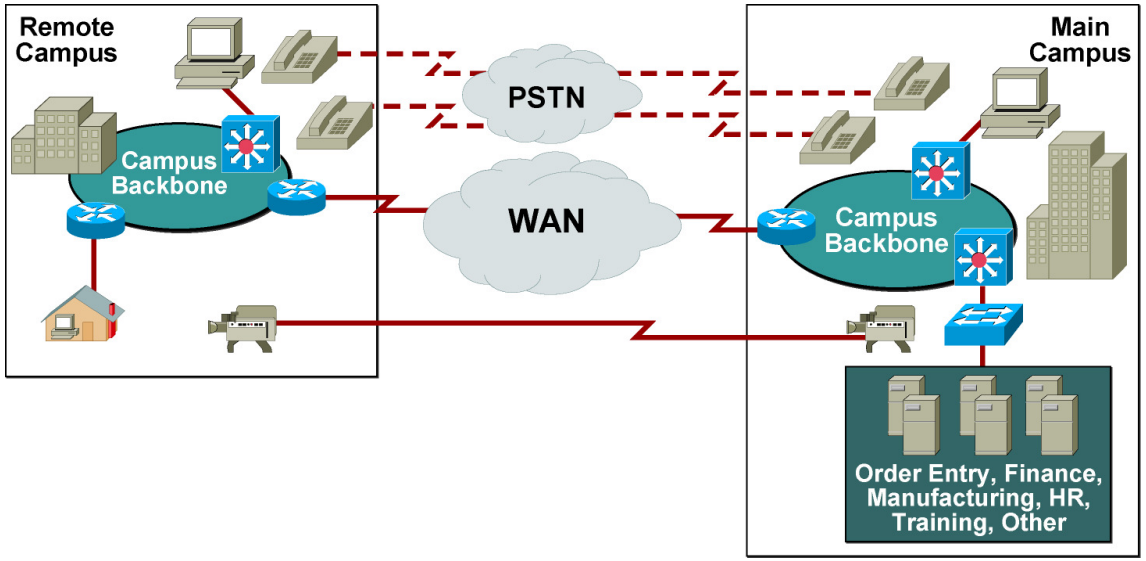
WLAN Troubleshooting Example 2



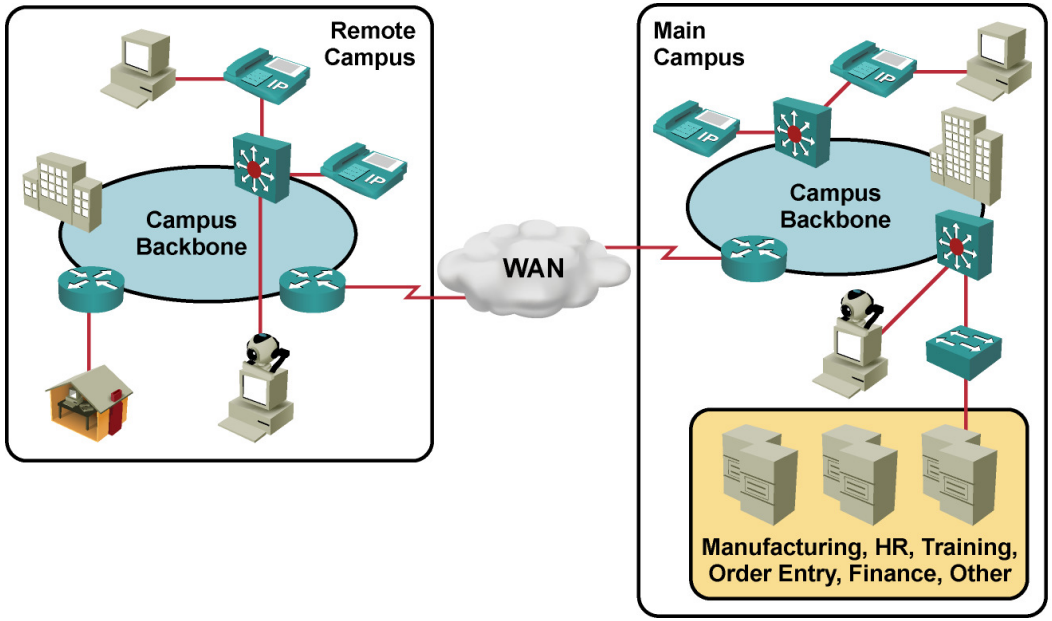

```
SW1(config)#int g0/34
SW1(config-if)#mls qos trust dscp
SW1(config-if)#end
SW1#end
SW1#
```

```
SW1#show mls qos int g0/34
GigabitEthernet0/34
trust state: trust dscp
trust mode: trust dscp
trust enabled flag: ena
COS override: dis
default COS: 0
DSCP Mutation Map: Default DSCP
Mutation Map
Trust device: None
qos mode: port-based
```

Converged Network Realities



- Traditional data traffic characteristics:
  - Bursty data flow
  - FIFO access
  - Not overly time-sensitive; delays OK
  - Brief outages are survivable



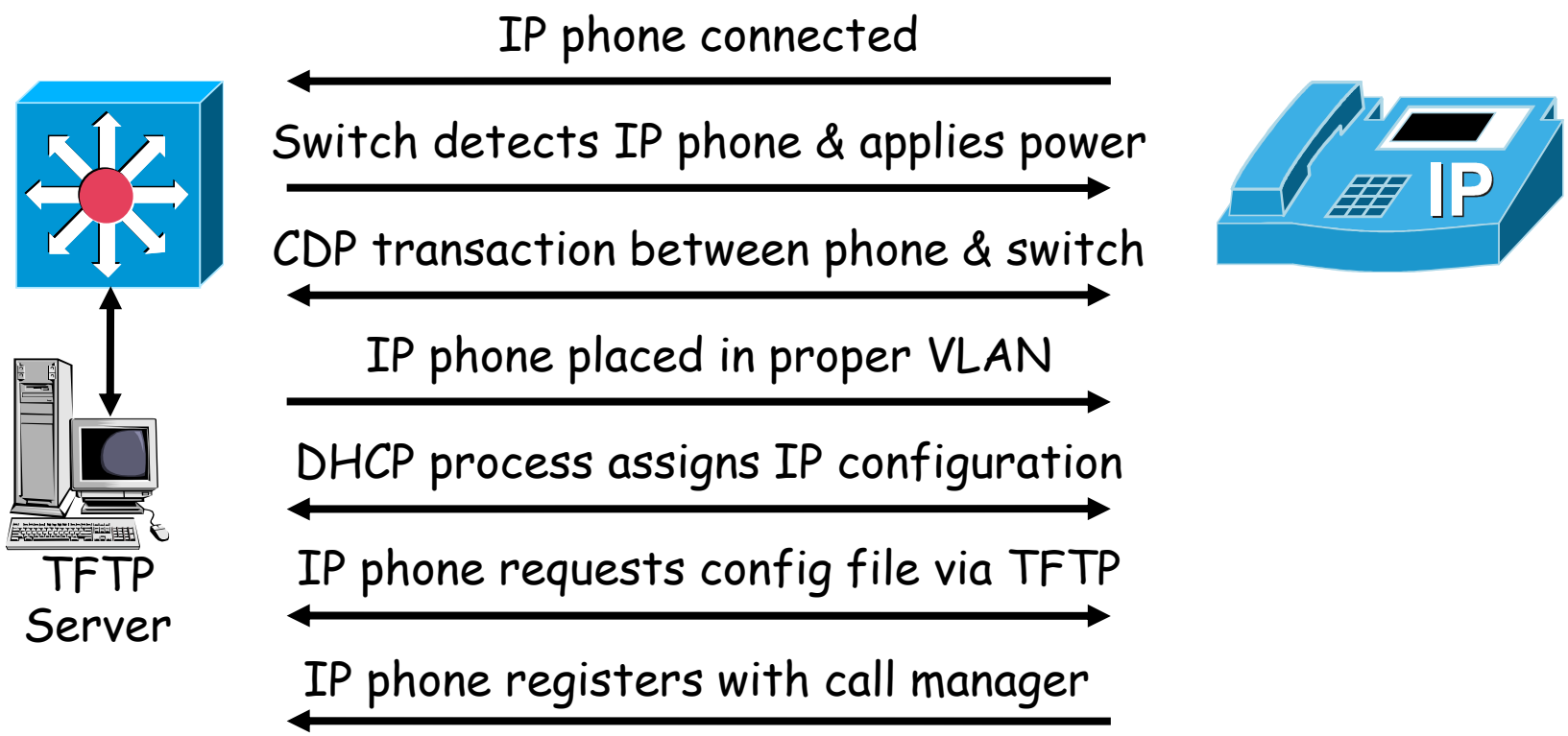
- Converged network realities:
  - Constant small-packet voice flow competes with bursty data flow.
  - Critical traffic must have priority.
  - Voice and video are time-sensitive.
  - Brief outages are not acceptable.

Unified Communications Design Considerations - Voice

- The following list summarizes the design considerations of integrating unified communications into a campus:

- *Quality of Service:* Bandwidth, delay, jitter, packet loss, Network QoS Readiness, Trust Boundaries, Switch QoS.
- *High Availability:* STP/RSTP, HSRP/GLBP/VRRP.
- *Security:* Traffic Segregation (Voice versus Data VLANs), Firewalling/Filtering.
- *Provisioning and Management:* PoE, DHCP, TFTP, NTP, CDP, Trunking, VLANs.

IP Phone Initialisation


IP phone connected
Switch detects IP phone & applies power
CDP transaction between phone & switch
IP phone placed in proper VLAN
DHCP process assigns IP configuration
IP phone requests config file via TFTP
IP phone registers with call manager
IP
TFTP Server

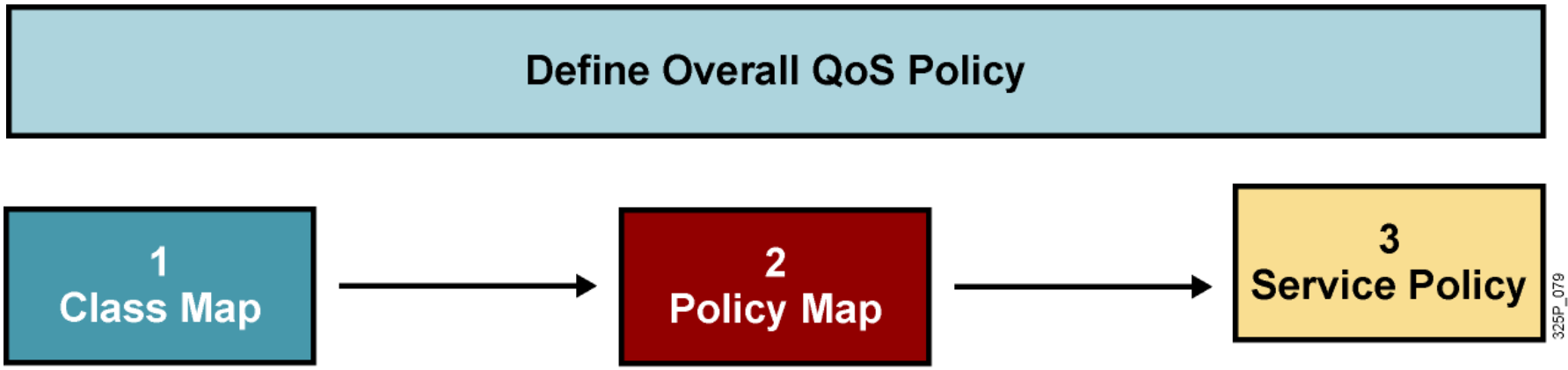
•If the services that the network infrastructure needs to provide are not available, are mis-configured, or are simply not reachable, IP phones might not be able to operate.

IP Phone VLAN Considerations

```
SW1(config)#int fa0/11
SW1(config-if)#switchport mode access
SW1(config-if)#switchport voice vlan 110
SW1(config-if)#switchport access vlan 10
```

- The link mode between the IP phone and the switch is negotiated; the switch instructs the phone to use a *special-case 802.1Q* trunk or a single VLAN access link.
- With a trunk, the voice traffic can be *isolated* from other user data, providing security and QoS capabilities.
- To configure the IP phone uplink, configure the switch port where it connects. The switch port does not need any special trunking configuration commands if a trunk is wanted.
- If an 802.1Q trunk is needed, a special-case trunk is *automatically* negotiated by *DTP* and *CDP*.

Modular QoS CLI Components



Define classes of traffic.

"What traffic do we care about?"

Each class of traffic is defined using a class map.

Define QoS policies for classes.

"What will be done to this traffic?"

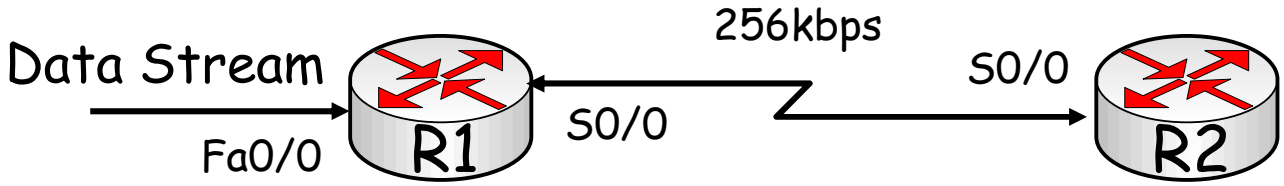
Defines a policy map, which configures the QoS features associated with a traffic class previously identified using a class map.

Apply a service policy.

"Where will this policy be implemented?"

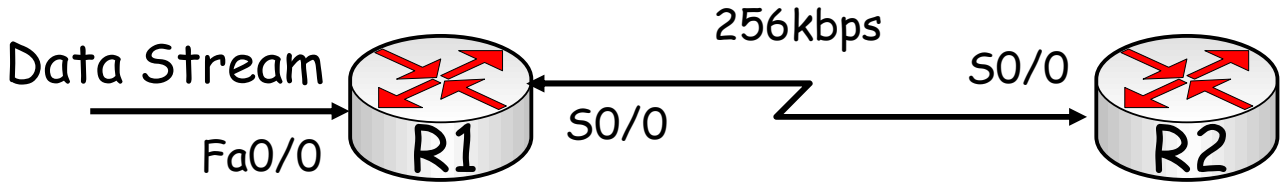
Attaches a service policy configured with a policy map to an interface.

Step 1: Creating Class Maps




```
R1(config)# access-list 101 permit tcp any any eq 22
R1(config)# access-list 102 permit tcp any any eq 80

R1(config)# class-map match any class1
R1(config-cmap)# match access-group 101
R1(config-cmap)# exit
R1(config)# class-map match any class2
R1(config-cmap)# match access-group 102
R1(config-cmap)# exit

R1(config)# class-map match any noip
R1(config-cmap)# match not protocol ip
R1(config-cmap)# exit
```

Step 2: Creating Policy Maps

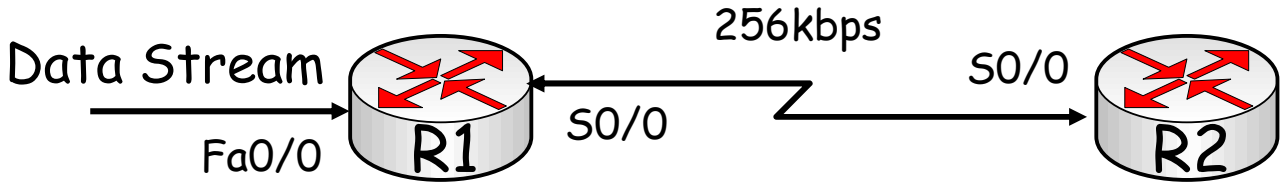



```
R1(config)# policy-map policy1
R1(config-pmap)# class class1
R1(config-pmap-c)# bandwidth 100
R1(config-pmap-c)# queue-limit 30

R1(config-pmap)# exit
R1(config-pmap)# class class2
R1(config-pmap-c)# bandwidth 80
R1(config-pmap)# exit
```

Nested Policy:

```
R1(config)# policy-map 1
R1(config-pmap)# class class1
R1(config-pmap-c)# bandwidth 50
R1(config-pmap-c)# class2
R1(config-pmap-c)# bandwidth 40

R1(config)# policy-map 2
R1(config-pmap)# class class-
default
R1(config-pmap-c)# shape average
128000
R1(config-pmap-c)# service-policy 1
```

Step 3: Apply Service Policy




```
R1(config)# interface s0/0
R1(config-if)# service-policy output policy1
R1(config-if)# exit
```

- Although you can assign the same traffic policy to multiple interfaces, each interface can have only *one* traffic policy attached at the *input* and only *one* traffic policy attached at the *output*.

Basic Verification Commands

R1# **show class-map**
Class Map match-any class-default (id 0)
Match any

Class Map match-all MUSIC (id 2)
Match protocol kazaa2

Class Map match-any EMAIL (id 1)
Match protocol pop3
Match protocol imap
Match protocol smtp

Class Map match-all VOICE (id 3)
Match protocol rtp audio

R1# **show policy-map**
Policy Map TSHOOT-EXAMPLE
Class EMAIL
Bandwidth 128 (kbps) Max Threshold 64 (packets)

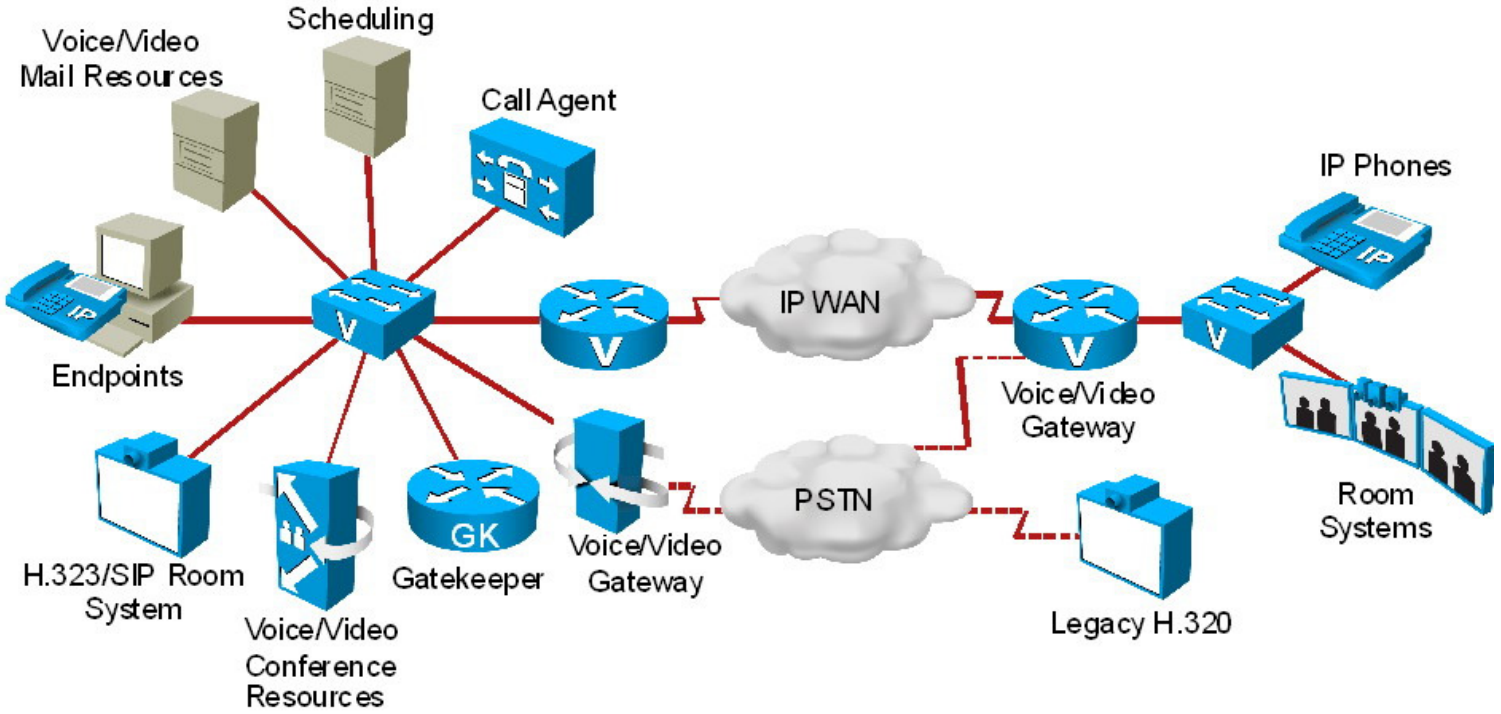
Class MUSIC
police cir 32000 bc 1500
conform-action transmit
exceed-action drop

Class VOICE
Strict Priority
Bandwidth 256 (kbps) Burst 6400 (Bytes)

Basic Verification Commands

```
R1# show policy-map interface serial0/1
Serial0/1
Service-policy output: TSHOOT-EXAMPLE
Class-map: EMAIL (match-any)
0 packets, 0 bytes
5 minute offered rate 0 bps, drop rate 0 bps
Match: protocol pop3
0 packets, 0 bytes
5 minute rate 0 bps
Match: protocol imap
0 packets, 0 bytes
5 minute rate 0 bps
Match: protocol smtp
0 packets, 0 bytes
5 minute rate 0 bps
Queueing
Output Queue: Conversation 265
Bandwidth 128 (kbps) Max Threshold 64
(packets)
(pkts matched/bytes matched) 0/0
(depth/total drops/no-buffer drops) 0/0/0
```

Unified Communications Design Considerations - Video



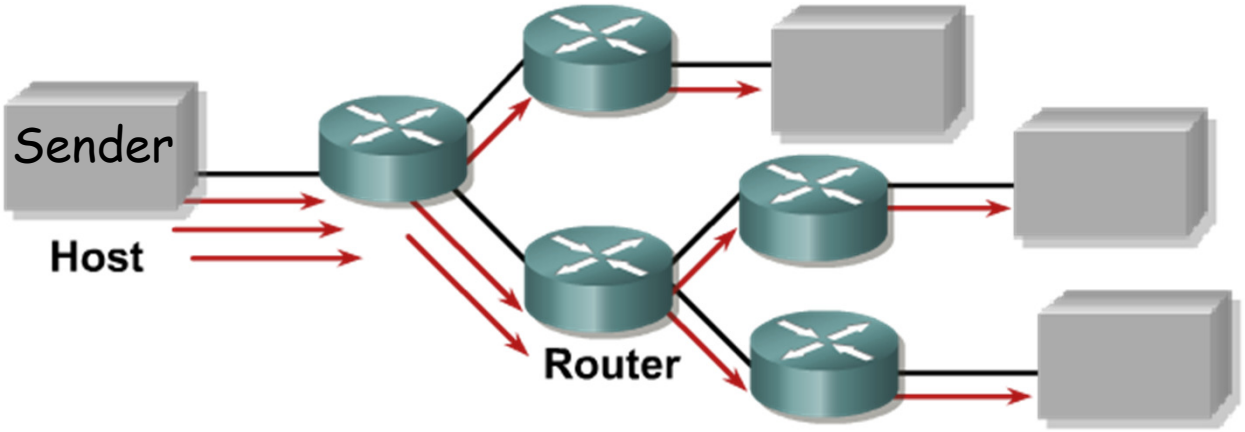
•Like voice traffic, video traffic is latency-sensitive. Therefore, many of the same design and troubleshooting considerations for voice traffic (for example, QoS considerations) also apply to video traffic.

Unified Communications Design Considerations - Video

- Due to the bandwidth-intensive and latency-sensitive nature of video, consider the following when designing or troubleshooting a video network:
- **QoS:** Like voice, video packets need to be allocated an appropriate amount of bandwidth and be treated with high priority.
- **Availability:** Also like voice, video networks should be built on an underlying data network with reliable components and redundancy.
- **Security:** Appropriate security measures, such as encryption and authentication, should be in place in a video network.
- **Multicasting:** Multicasting allows a multicast server to send traffic (for example, a video stream) to a destination Class D IP address known as a *multicast group.*

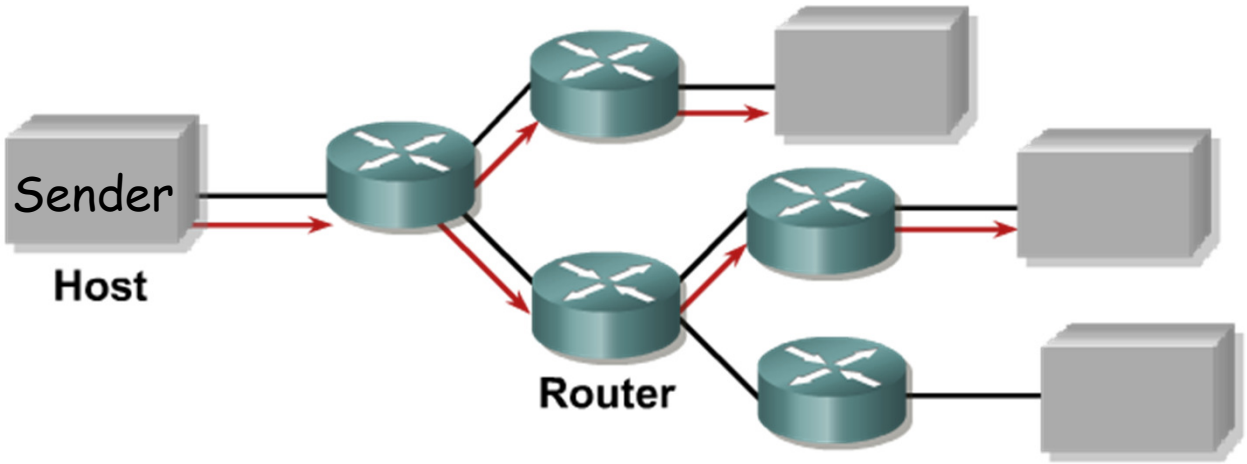
Unicast vs. Multicast

Unicast



- Sender has to send the same data flow to each receiver separately.
- The sender has to make *copies* of the same packet and send them once for each receiver.

Multicast



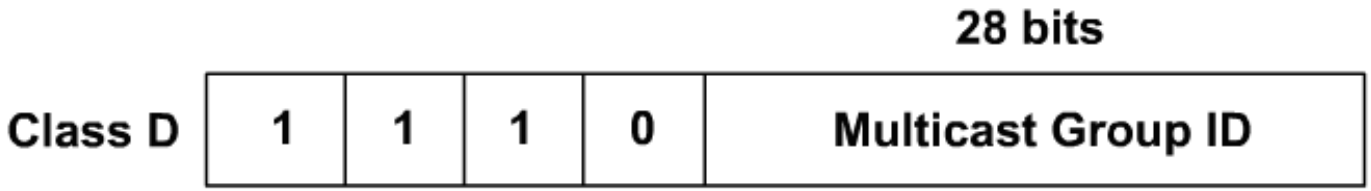
- Data packets are sent to multiple receivers - the packets are not duplicated for every receiver but are sent in a single stream.
- Downstream routers perform *packet multiplication* over receiving links when necessary

Access control and threat management mechanisms need to consider the various protocols and traffic flows that result from a video-enabled network, e.g. SIP, H.323, SCCP (Skinny), RTP, RTCP

IP Multicast Address Structure

IP group addresses:

- Class D address (high-order three bits are set)
- Range from 224.0.0.0 through 239.255.255.255



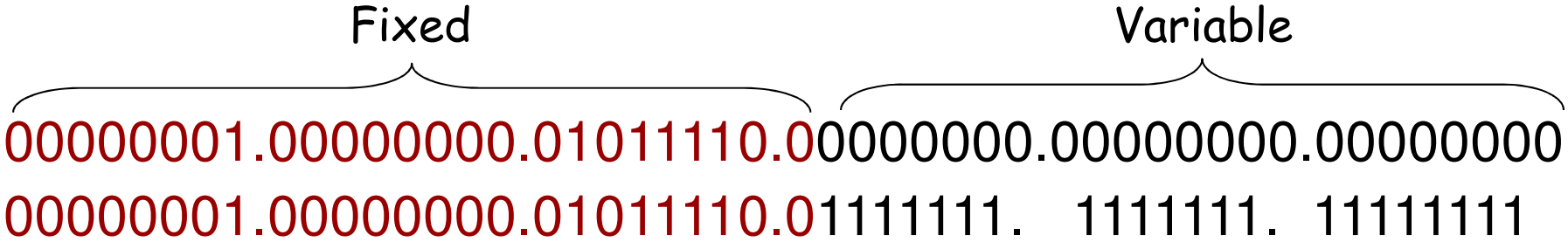
- Local scope addresses
  224.0.0.0 to 224.0.0.255

- Global scope addresses
  224.0.1.0 to 238.255.255.255

- Administratively scoped addresses
  239.0.0.0 to 239.255.255.255

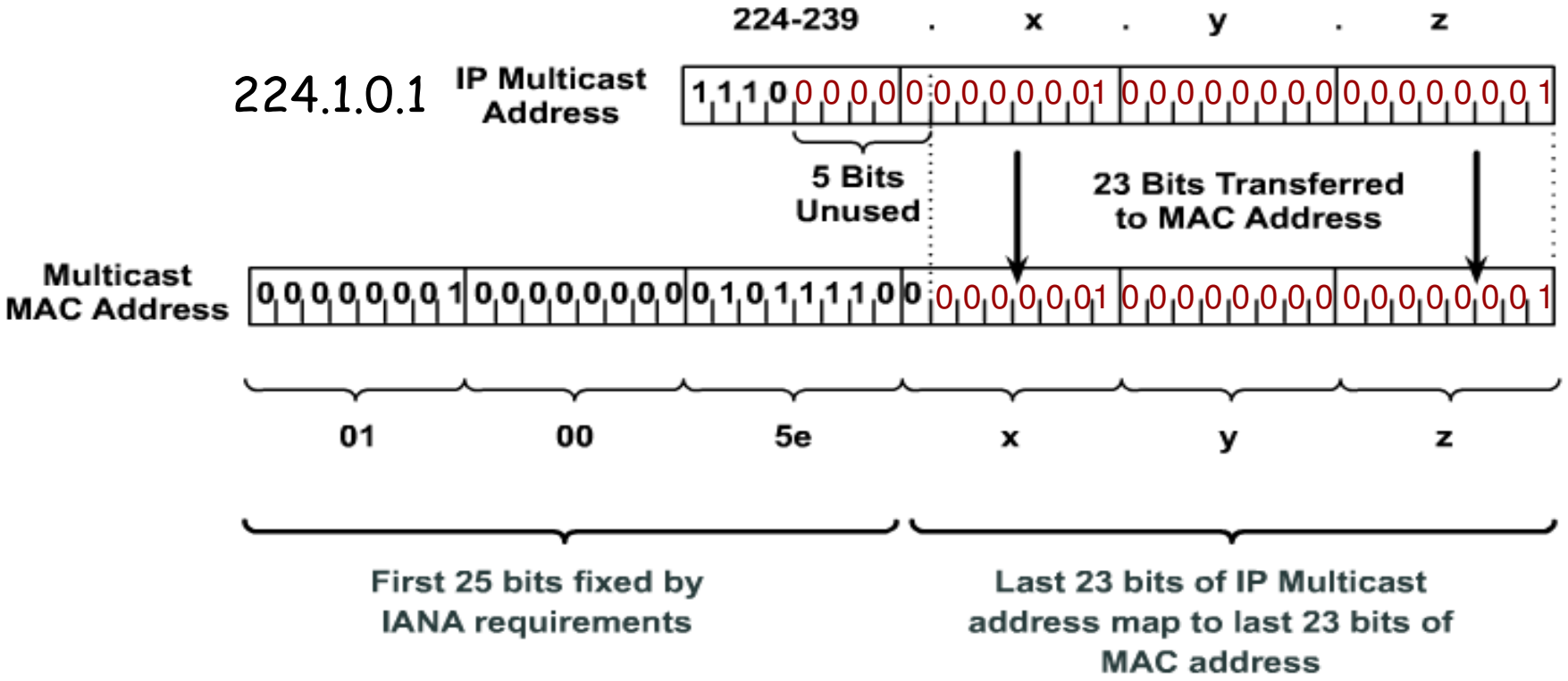
IANA Ethernet MAC Address Range

- Normally, network interface cards (NICs) on a LAN segment only receive packets destined for their burned-in MAC address. However, there is no *Address Resolution Protocol* (ARP) equivalent for multicast address mapping.
- IANA has set aside the vendor code portion of the reserved Organizationally Unique Identifier (OUI) value to identify multicast MAC addresses.
- Multicast MAC addresses always begin with the low-order bit (0x01) in the first octet. Specifically, the *0x01005e* prefix (plus the next lower bit, which is zero) has been reserved for mapping Layer 3 IP multicast addresses into Layer 2 MAC addresses.
- The complete multicast MAC address range is from 0100.5e00.0000 through 0100.5e7f.ffff.



IP Multicast to MAC Multicast Mapping

- The translation between IP multicast and MAC address is achieved by the mapping of the low-order 23 bits of the IP (Layer 3) multicast address into the low-order 23 bits of the IEEE (Layer 2) MAC address.


224-239 . x . y . z
224.1.0.1
IP Multicast Address
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
5 Bits Unused
23 Bits Transferred to MAC Address
Multicast MAC Address
0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 1 1 1 1 1 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
01 00 5e x y z
First 25 bits fixed by IANA requirements
Last 23 bits of IP Multicast address map to last 23 bits of MAC address

0100.5e01.0001

IANA Ethernet MAC Address Range

- This gives the possibility that 32 different multicast IP addresses could all correspond to a single multicast MAC address:

11100000.00000001.00000000.00000001 = 224.1.0.1

11101111.00000001.00000000.00000001 = 239.1.0.1

11100000.10000001.00000000.00000001 = 224.129.0.1

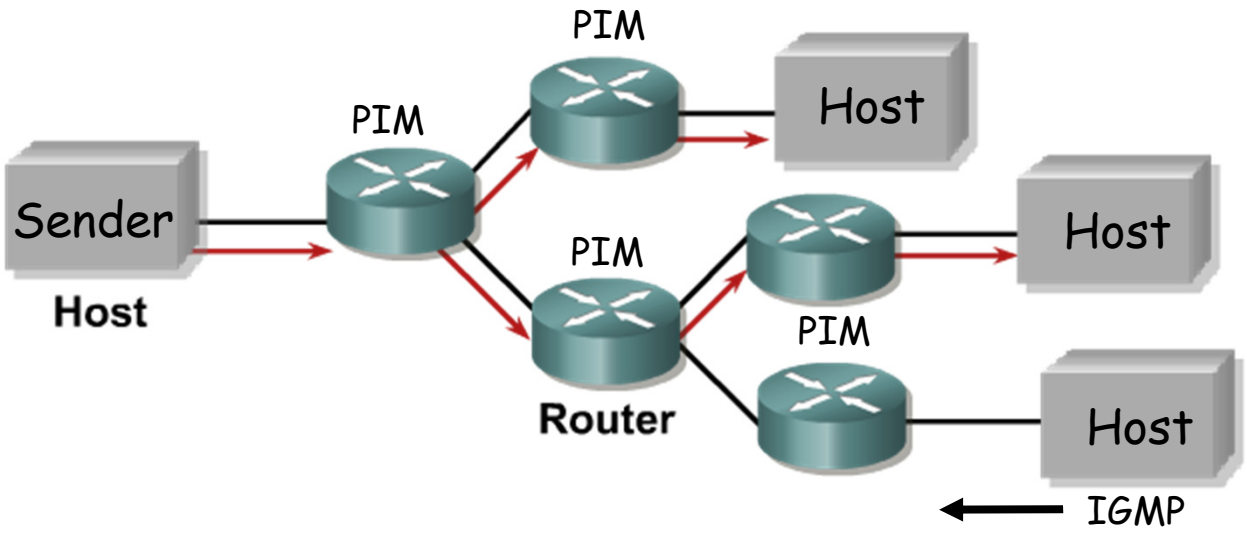
11101111.10000001.00000000.00000001 = 239.129.0.1

How are Multicast Addresses Assigned?

Static Global Group Address Assignment:

- Temporary method to meet immediate needs
- Group range: 233.0.0.0 – 233.255.255.255
  - Your AS number is inserted in middle two octets
  - Remaining low-order octet used for group assignment
- Defined in RFC 2770
  - "GLOP Addressing in 233/8"
- Manual address allocation by the admin is still the most common practice.

Multicast Protocols

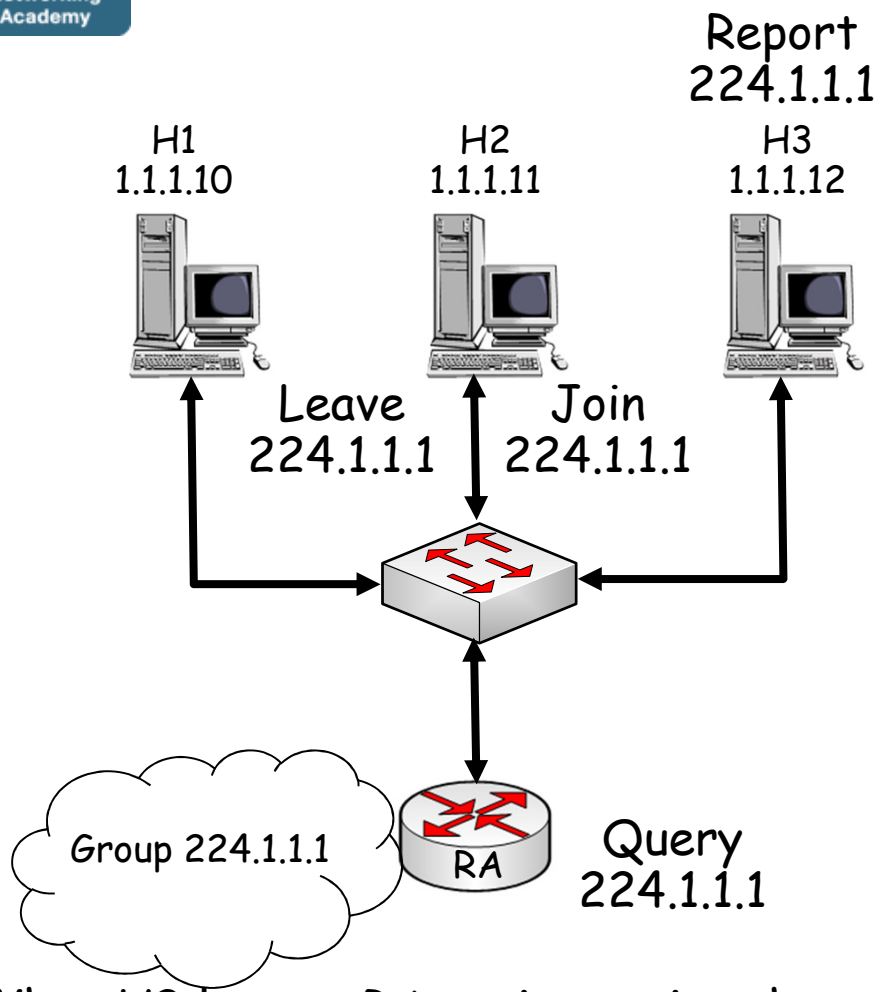


- There are two main protocols involved in a multicast enabled:
- Routers will run a multicast routing protocol, typically *Protocol Independent Multicast* (PIM) whose main role is to advertise the location of multicast receivers.
- The second main component is the way hosts subscribe to groups, and announce themselves as members of the group, which is typically done using *Internet Group Management Protocol* (IGMP).

Internet Group Management Protocol (IGMP)

- How hosts tell routers about group membership.
- Routers solicit group membership from directly connected hosts.
  - RFC 1112 specifies IGMPv1
    - Supported on Windows 95
  - RFC 2236 specifies IGMPv2
    - Supported on latest service pack for Windows and most UNIX systems
  - RFC 3376 specifies IGMPv3
    - Supported in Window XP and various UNIX systems

IGMPv2 Operation



- Members joining a multicast group do not have to wait for a query to join. They send an unsolicited report indicating their interest.

- RA hears the leave message and sends a group-specific *query* to see if any other group members are present. H3 has not left the multicast group 224.1.1.1 yet, so it responds with a *report* message.

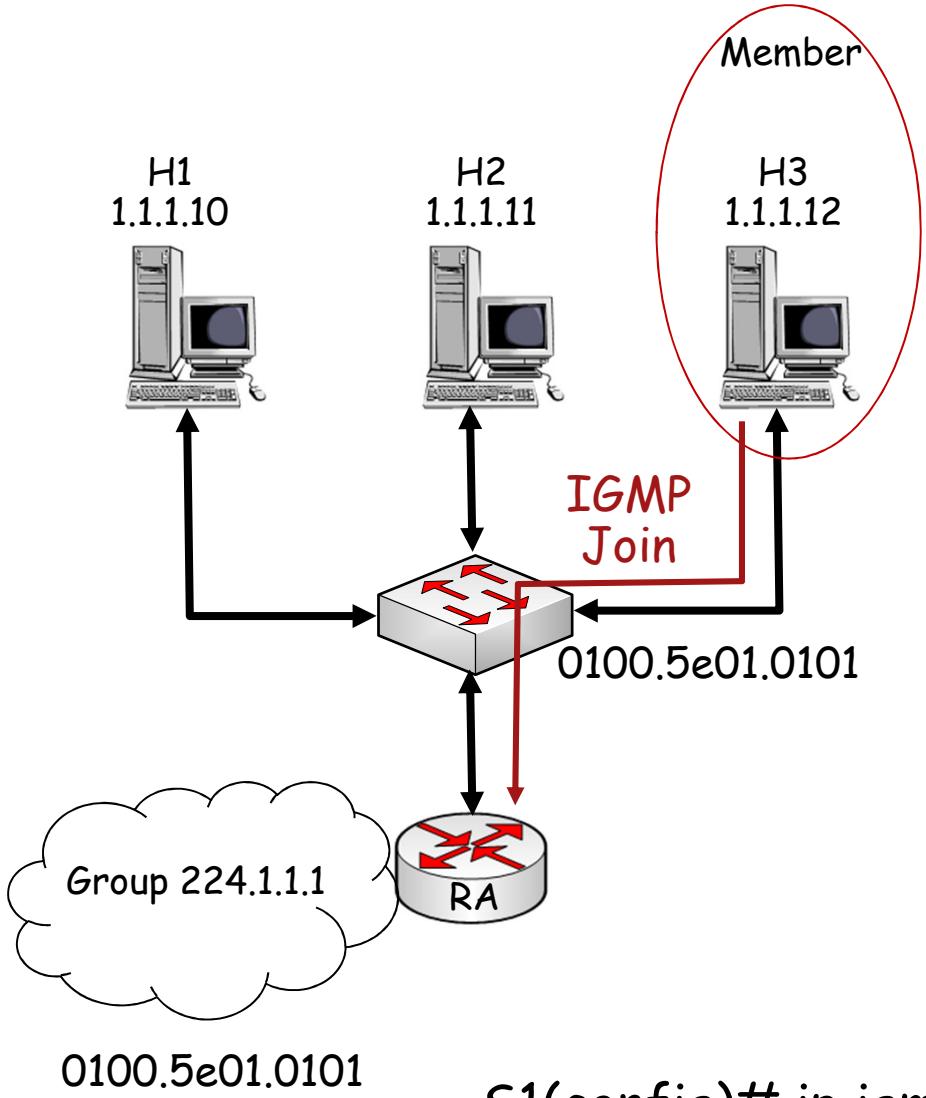
```
rtr-a>show ip igmp group
IGMP Connected Group Membership
Group Address    Interface    Uptime    Expires   Last Reporter
224.1.1.1        Ethernet0    0d1h3m    00:02:31  1.1.1.11
```

```
rtr-a>show ip igmp group
IGMP Connected Group Membership
Group Address    Interface    Uptime    Expires   Last Reporter
224.1.1.1        Ethernet0    0d1h3m    00:02:31  1.1.1.12
```

```
rtr-a>show ip igmp group
IGMP Connected Group Membership
Group Address    Interface    Uptime    Expires   Last Reporter
```

When H3 leaves, RA again queries the group. Because host H3 was the last remaining member of the multicast group 224.1.1.1, no IGMP membership report for group 224.1.1.1 is received, and the group times out.

IGMP Snooping



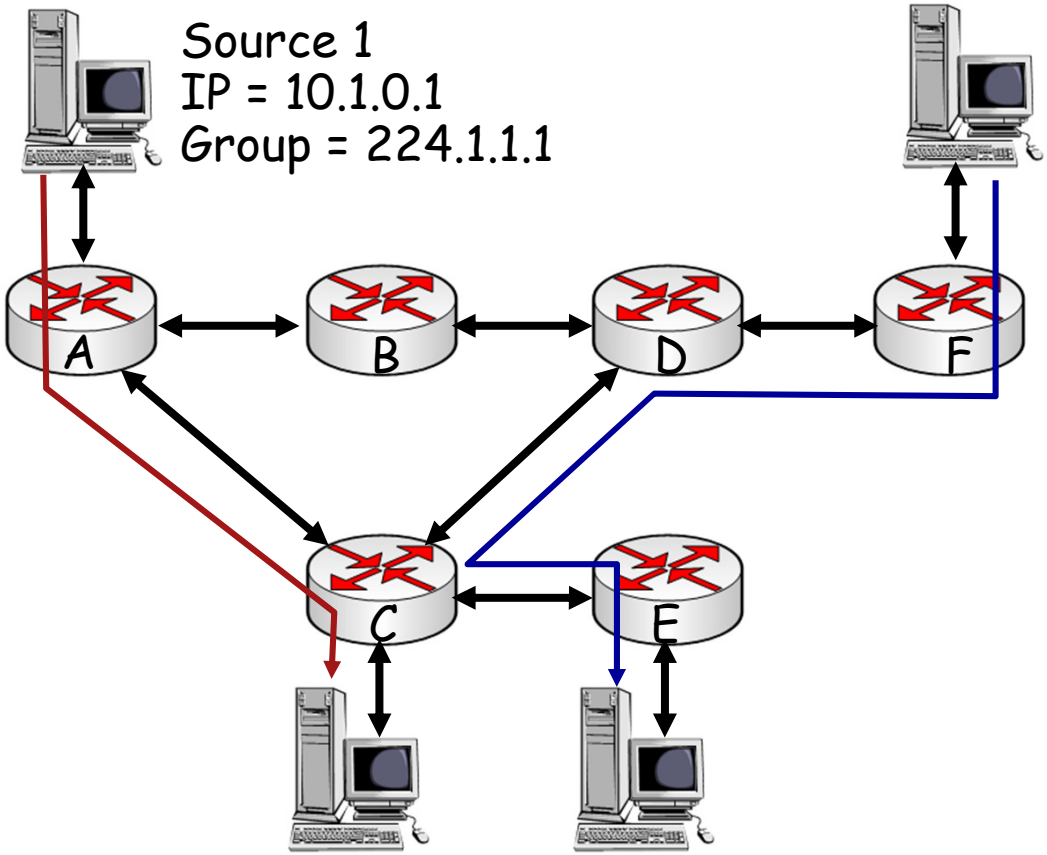
- Switches become IGMP-aware.
- IGMP packets are intercepted by the CPU or by special hardware ASICs.
- Switch examines contents of IGMP messages to learn which ports want what traffic.
- Must process all Layer 2 multicast packets.
- Administration load increased with multicast traffic load.

```
S1(config)# ip igmp snooping
S1(config)# ip igmp snooping vlan 10
```

Verify Group State

```
R1#show ip igmp interface
Serial0/0/0 is up, line protocol is up
Internet address is 10.23.23.2/24
IGMP is enabled on interface
Current IGMP host version is 2
Current IGMP router version is 2
IGMP query interval is 60 seconds
IGMP querier timeout is 120 seconds
IGMP max query response time is 10 seconds
Last member query count is 2
Last member query response interval is 1000 ms
Inbound IGMP access group is not set
IGMP activity: 1 joins, 0 leaves
Multicast routing is enabled on interface
Multicast TTL threshold is 0
IGMP querying router is 0.0.0.0 (this system)
Multicast groups joined by this system (number of users):
224.0.1.40(1)
```

Multicast Routing Protocols – Source Distribution Tree

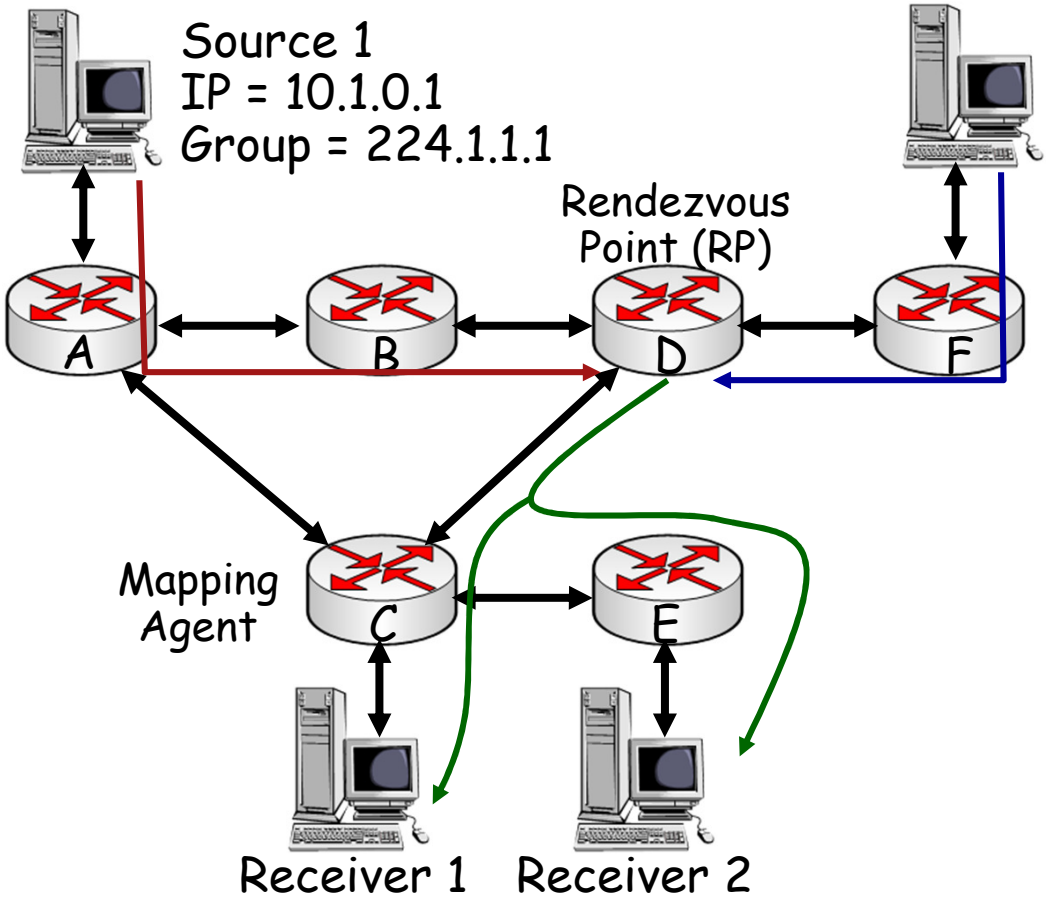


- With a source tree, a *separate* tree is built for each source to all members of its group.

- Because the source tree takes the *shortest* path from the source to its receivers, it is also called a shortest path tree (SPT).

Notation: (S,G)
S = Source
G = Group

Multicast Routing Protocols – Shared Tree



- Shared tree protocols create multicast forwarding paths that rely on a central core router that serves as a *rendezvous point (RP)* between multicast sources and destinations.

- Sources initially send their multicast packets to the RP, which in turn forwards data through a *shared tree* to the members of the group.

Notation: (*,G)
S = Source
G = Group

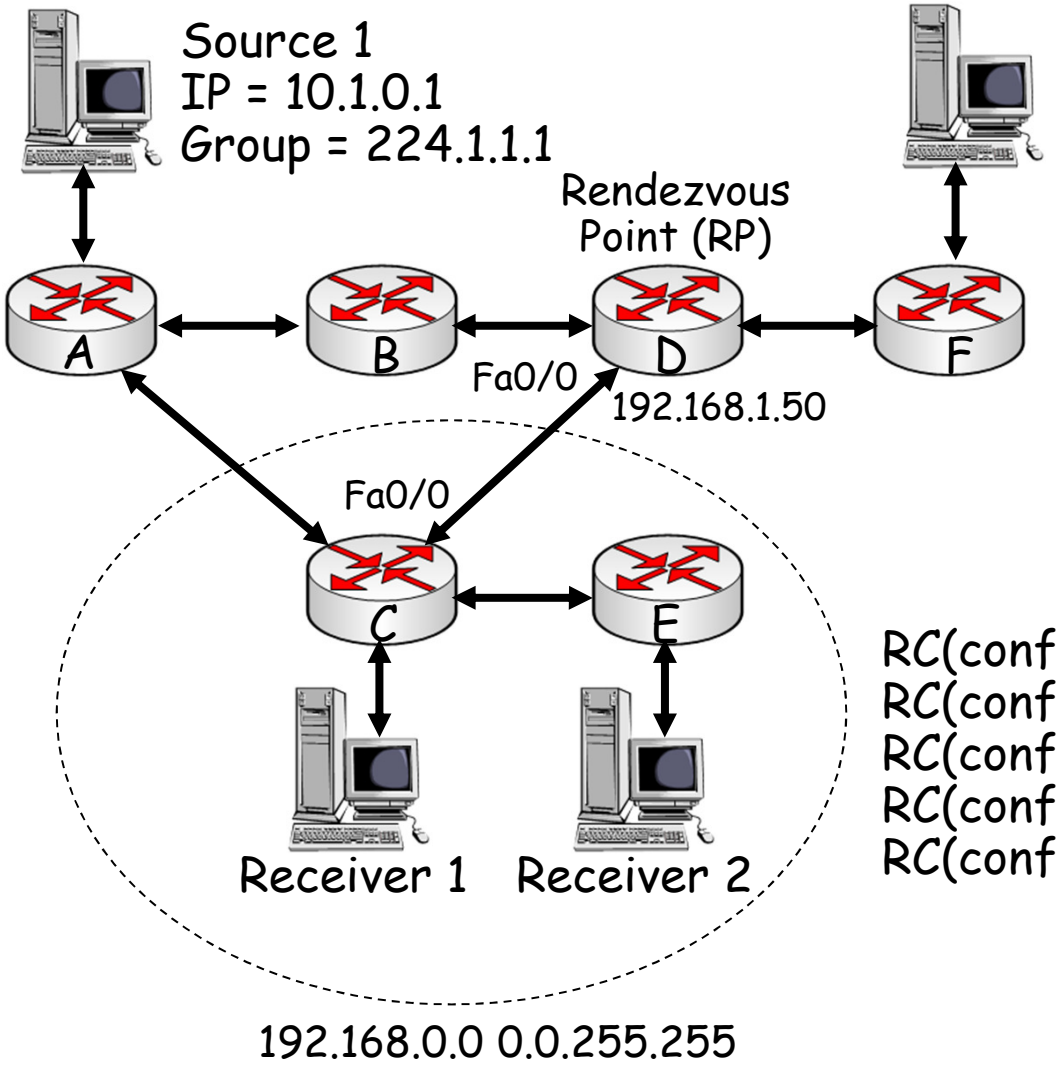
Auto-RP

- Auto –RP is a Cisco proprietary method of automatically selecting an RP. Auto-RP identifies a centrally located router to act as a *mapping agent*.
- The mapping agent learns of all candidate RPs on *224.0.1.39* (all PIM-routers automatically join this group).
- The mapping agent advertises all candidate RPs on *224.0.1.40*.

Protocol-Independent Multicast (PIM)

- PIM maintains the current IP multicast service mode of receiver-initiated membership.
- PIM is not dependent on a specific unicast routing protocol.
- With PIM, routers maintain forwarding tables to forward multicast datagrams.
- PIM can operate in *dense mode* or *sparse mode:*
  - *Dense mode* protocols flood multicast traffic to all parts of the network and prune the flows where there are no receivers using a periodic flood-and-prune mechanism.
  - *Sparse mode* protocols use an explicit join mechanism where distribution trees are built on demand by explicit tree join messages sent by routers that have directly connected receivers.

PIM Configuration




```
RD(config)#ip multicast routing
RD(config)#interface fa0/0
RD(config-if)#ip pim dense-mode
or
RD(config-if)#ip pim sparse-mode
or
RD(config-if)#ip pim sparse-dense-
mode
```

```
RC(config)#ip multicast routing
RC(config)#interface fa0/0
RC(config-if)#ip pim sparse-dense-mode
RC(config-if)#exit
RC(config)#ip pim rp-address 192.168.1.50
```

Verify PIM Neighbours

```
R1#show ip pim interface
Address          Interface            Ver/   Nbr    Query  DR     DR
                                      Mode   Count  Intvl  Prior
10.139.16.133    Serial0/0            v2/S   1      30     1      0.0.0.0
10.127.0.170     Serial1/2            v2/S   1      30     1      0.0.0.0
10.127.0.242     Serial1/3            v2/S   1      30     1      0.0.0.0
```

```
R1#show ip pim neighbor
PIM Neighbor Table
Neighbor         Interface            Uptime/Expires       Ver    DR
Address                                                           Priority
10.139.16.134    Serial0/0            00:01:46/00:01:28    v2     1
10.127.0.169     Serial1/2            00:01:05/00:01:40    v2     1
10.127.0.241     Serial1/3            00:01:56/00:01:18    v2     1
```

Verify PIM Routing

```
R1# show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C -
Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement
U - URD, I - Received Source Specific Host Report, Z - Multicast
Tunnel,
Y - Joined MDT-data group, y - Sending to MDT-data group
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.0.100.4), 02:37:12, RP is 192.168.47.14, flags: S
Incoming interface: Serial0, RPF neighbor 10.4.53.4
Outgoing interface list:
Ethernet1, Forward/Sparse, 02:37:12/0:03:42
Ethernet2, Forward/Sparse, 02:52:12/0:01:23

(192.168.46.0/24, 224.0.100.4), 02:37:12, flags: RT
Incoming interface: Ethernet1, RPF neighbor 10.4.53.4
Outgoing interface list:
Ethernet2, Forward/Sparse, 02:44:21/0:01:47
```

Chapter 8 – Troubleshooting Converged Networks
Objectives

- Explain the operation of the Cisco Centralised Wireless model.
- Describe LWAPP operation & troubleshooting techniques.
- Explain the requirement for QoS converged networks.
- Describe basic QoS operation & troubleshooting techniques.
- Describe basic multicast operation & troubleshooting techniques.

Any Questions?